

HYDRO STATICS

INTRODUCTION

Introduction

Pressure

In fluids we use the term pressure to mean:

The perpendicular force exerted by a fluid per unit area.

This is equivalent to stress in solids, but we shall keep the term pressure. Mathematically, because pressure may vary from place to place, we have:

$$p = \lim_{\Delta \rightarrow 0} \frac{\Delta F}{\Delta A}$$

As we saw, force per unit area is measured in N/m^2 which is the same as a Pascal (Pa). The units used in practice vary:

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Pressure

- $1 \text{ kPa} = 1000 \text{ Pa} = 1000 \text{ N/m}^2$
- $1 \text{ MPa} = 1000 \text{ kPa} = 1 \times 10^6 \text{ N/m}^2$
- $1 \text{ bar} = 10^5 \text{ Pa} = 100 \text{ kPa} = 0.1 \text{ MPa}$
- $1 \text{ atm} = 101,325 \text{ Pa} = 101.325 \text{ kPa} = 1.01325 \text{ bars} = 1013.25 \text{ millibars}$

For reference to pressures encountered on the street which are often imperial:

- $1 \text{ atm} = 14.696 \text{ psi}$ (i.e. pounds per square inch)
- $1 \text{ psi} = 6894.7 \text{ Pa} \approx 6.89 \text{ kPa} \approx 0.007 \text{ MPa}$

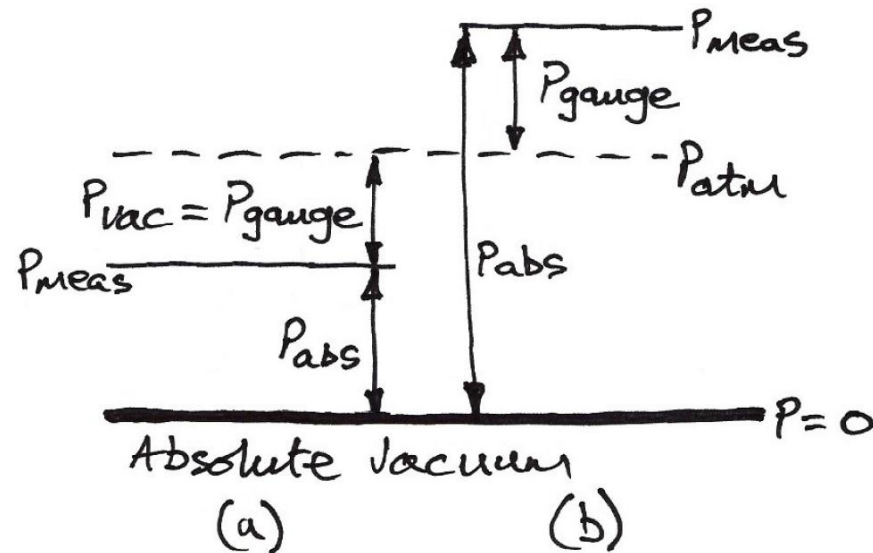
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Pressure Reference Levels

The pressure that exists anywhere in the universe is called absolute pressure, P_{abs} . This then is the amount of pressure greater than a pure vacuum. The atmosphere on earth exerts atmospheric pressure, P_{atm} , on everything in it. Often when measuring pressures we will calibrate the instrument to read zero in the open air. Any measured pressure, P_{meas} , is then a positive or negative deviation from atmospheric pressure. We call such deviations a gauge pressure, P_{gauge} . Sometimes when a gauge pressure is negative it is termed a vacuum pressure, P_{vac} .

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Pressure Reference Levels



(a) The case when the measured pressure is below atmospheric pressure and so is a negative gauge pressure or a vacuum pressure.

(b) The more usual case when the measured pressure is greater than atmospheric pressure by the gauge pressure.

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Pressure Reference Levels

- (a) *Absolute pressure* is defined as the pressure which is measured with reference to absolute vacuum pressure.
- (b) *Gauge pressure* is defined as the pressure which is measured with the help of a pressure measuring instrument, in which the atmospheric pressure is taken as datum. The atmospheric pressure on the scale is marked as zero.
- (c) *Vacuum pressure* is defined as the pressure below the atmospheric pressure.

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Pressure Reference Levels

Under normal conditions at sea level:

$$P_{atm} = 2166 \text{ lb/ft}^2$$

$$= 14.7 \text{ psi}$$

$$= 29.9 \text{ inches of mercury (Hg)}$$

$$= 760 \text{ mm Hg}$$

$$= 101.325 \text{ kPa}$$

Mathematically:

$$\text{Absolute Pressure, } P_{abs} = P_{atm} + P_{gauge}$$

$$\text{Vacuum Pressure, } P_{vac} = P_{atm} - P_{abs}$$